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UNITED STATES PATENT APPLICATION

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FOR

COMPOSITIONS COMPRISING AT LEAST ONE C_1 TO C_{22} SUBSTITUTED C_3 TO C_5 MONOSACCHARIDE, AND THEIR USE FOR THE PROTECTION AND/OR REPAIR OF KERATINOUS FIBERS

The present invention relates to compositions, kits comprising these compositions, and methods for using these compositions for repairing or for protecting from extrinsic damage at least one keratinous fiber, including human keratinous fibers, by applying to the at least one keratinous fiber compositions which comprise at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, and, in certain embodiments, at least one film forming agent different from the at least one compound, and heating the at least one keratinous fiber. These compositions may both protect and repair the at least one keratinous fiber.

Keratinous fibers, and especially hair, are constantly exposed to harsh extrinsic conditions such as sun (*i.e.,* UV radiation), chemical damage (for example, from detergents, bleaching, relaxing, dyeing, and permanent waving), and heat (for example, from hair dryers or curlers). These external factors generally result in damage to the keratinous fibers. More specifically, extrinsic conditions may disrupt the organized structure of the keratinous fibers, called the α-structure, which may be accompanied by a decrease in their tensile strength. The extrinsic damage to keratinous fibers, as one would imagine, is more evident the further the fiber has grown from the root, because the fiber has been exposed longer to the elements. In effect, the fibers have what may be called a "damage history" as they grow, *i.e.,* generally, further from the root, the tensile strength of the fiber is lower and the breakdown in the α-structure of the fiber that has occurred is greater.

Morphologically, a keratinous fiber contains four structural units: cuticle, cortex, medulla, and intercellular cement. Robbins, C.R. Chemical and Physical Behavior of Human Hair, 3rd Edition, Springer-Verlag (1994). The cuticle layers are located on the fiber surface and consist of flat overlapping cells ("scales"). These scales are attached at the root end and point toward the distal (tip) end of the fiber and form layers around the fiber cortex . The cortex comprises the major part of the fiber. The cortex consists of spindle-shaped cells, macrofibrils, that are aligned along the fiber axis. The macrofibrils further consist of microfibrils (highly organized protein units) that are embedded in the matrix of amorphous protein structure. The medulla is a porous region in the center of the fiber. The medulla is a common part of wool fibers but is found only in thicker human keratinous fibers. Finally, the intercellular cement is the material that binds the cells together, forming the major pathway for diffusion into the fibers.

The mechanical properties of the keratinous fibers are determined by the cortex. A two-phase model for the cortex organization has been suggested. Milczarek et al, Colloid Polym. Sci., 270, 1106-1115 (1992). In this model, water-impenetrable microfilaments ("rods") are oriented parallel with the fiber axis. The microfilaments are embedded in a water-penetrable matrix ("cement"). Within the microfilaments, coiled protein molecules are arranged in a specific and highly organized way, representing a degree of crystallinity in the fiber.

Similar to other crystalline structures, keratinous fibers display a distinct diffraction pattern when examined by wide-angle X-ray diffraction. In normal, non-stretched

keratinous fibers this pattern is called an "alpha-pattern". The alpha-pattern or α-structure of hair is characterized by specific repeated spacings (9.8 Å, 5.1 Å, and 1.5Å). All proteins that display this X-ray diffraction pattern are called α-proteins and include, among others, human hair and nails, wool, and porcupine quill. When the fiber is stretched in water, a new X-ray diffraction pattern emerges that is called a "β-pattern", with new spacings (9.8 Å, 4.65 Å, and 3.3 Å).

It is the α-structure of the cortex of the fiber that is sensitive to damage by extrinsic conditions. When normal keratinous fibers are damaged by heat, chemical treatment, or UV radiation, a decrease in the crystallinity or α-structure and a decrease in the number of disulfide bonds are observed. There is a need, therefore, for products that are useful in protecting the α-structure of keratinous fibers from harsh extrinsic conditions and restoring the α-structure following damage by extrinsic conditions.

The aforementioned products are, for example, cosmetic compositions containing sugars. Sugars and sugar derivatives are one class of the countless number of compounds that have been added to hair care compositions. Documented uses of sugars in hair care compositions include: the use of glucose to improve the tactile and elastic properties of natural hair (Hollenberg and Mueller, SOFW J. 121(2) (1995)); the use of glucose for hair damage prophylaxis and damaged hair repair (Hollenberg & Matzik, Seifen, Oele, Fette, Wachase 117(1) (1991)); the use of glucose in shampoos (J04266812, assigned to Lion Corp.); the use of trehalose for moisture retention (J06122614, assigned to Shiseido Co. Ltd.); a composition for the lanthionization of hair comprising a sugar (U.S.

Patent Nos. 5,348,737 and 5,641,477, assigned to Avlon Ind. Inc.); the incorporation of xylobiose into cosmetic compositions to provide enhanced moisture retention and reduce excessive roughness and dryness of the skin and hair (U.S. Patent No. 5,660,838, assigned to Suntory Ltd.); a composition for the regeneration of hair split-ends that contains at least one mono- or di-saccharide (U.S. Patent No. 4,900,545, assigned to Henkel); hair care compositions to improve hair strength, hold and volume that contain C_5 to C_6 carbohydrates such as glucose; the use of fucose in a hair treatment to prevent split ends (DE29709853, assigned to Goldwell GMBH); and the use of saccharides in a shampoo to improve combing properties and control hair damage (J09059134, assigned to Mikuchi Sangyo KK).

In essence, sugars have been applied to hair for countless reasons from moisturizing to enhancing hair growth (J10279439, assigned to Kureha Chem. Ind. Co. Ltd.). Clearly, however, not all sugars are the same and not all sugars impart the same properties when applied to a keratinous fiber. Additionally, the use of specific sugars that protect hair from extrinsic damage and, more particularly, protect the α-structure of hair from such damage has not been demonstrated. As a result, if sugars are going to be useful in protecting hair from extrinsic damage, a better understanding of the advantages of using sugars in hair care compositions is needed, and more specifically, an understanding of how sugars may be useful in restoring and protecting keratinous fibers.

The inventors have envisaged the application to at least one keratinous fiber of at least one composition comprising at least one compound chosen from C_3 to C_5

monosaccharides substituted with at least one C_1 to C_{22} carbon chain. In particular, the inventors have discovered that compositions and methods using these compositions comprising applying to the at least one keratinous fiber at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, and heating the at least one keratinous fiber are useful for repairing or for protecting from extrinsic damage the at least one keratinous fiber.

Thus, to achieve at least one of these and other advantages, the present invention, in one aspect, provides a method for protecting at least one keratinous fiber from extrinsic damage or repairing at least one keratinous fiber following extrinsic damage comprising applying to the at least one keratinous fiber a composition comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, and heating the at least one keratinous fiber, wherein the at least one compound is present in an amount effective to protect the at least one keratinous fiber from the extrinsic damage or to repair a damaged keratinous fiber, and further wherein the composition is applied prior to or during heating.

In another embodiment, the present invention is drawn to a method for protecting at least one keratinous fiber from extrinsic damage or repairing at least one keratinous fiber following extrinsic damage comprising applying to at least one keratinous fiber a composition comprising (i) at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain and (ii) at least

one film forming agent different from the at least one compound, and heating the at least one keratinous fiber, wherein the at least one compound and the at least one film forming agent are present in an amount effective to protect the keratinous fiber from extrinsic damage or to repair a damaged keratinous fiber, and further wherein the composition is applied prior to or during heating.

In another embodiment, the present invention is also drawn to compositions for protecting at least one keratinous fiber from extrinsic damage or repairing at least one keratinous fiber following extrinsic damage comprising (i) at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain and (ii) at least one film forming agent different from the at least one compound, wherein the at least one compound and the at least one film forming agent are present in an amount effective to protect the at least one keratinous fiber from the extrinsic damage or to repair a damaged keratinous fiber. In one embodiment, the composition is heat-activated.

Further, the present invention is also drawn to compositions for protecting at least one keratinous fiber from extrinsic damage or repairing at least one keratinous fiber following extrinsic damage comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, wherein the at least one compound is present in an amount effective to protect the at least one

keratinous fiber from the extrinsic damage or to repair a damaged keratinous fiber. In one embodiment, the composition is heat-activated.

In yet another embodiment, the present invention provides a kit for protecting at least one keratinous fiber from extrinsic damage or for repairing at least one keratinous fiber following extrinsic damage comprising at least one compartment, wherein a first compartment comprises a first composition comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain. In one embodiment, at least one compartment comprises at least one additional sugar, different from the at least one compound, and in another embodiment, at least one compartment comprises at least one film forming agent. In another embodiment, the kit further comprises a second compartment comprising a composition comprising at least one film forming agent.

Certain terms used herein are defined below:

"Extrinsic damage" as used herein means disruption of the α-structure, protein loss, and/or denaturing caused by exposure to extrinsic conditions.

"Extrinsic conditions" as used herein means heat (such as from hair dryers or curlers), chemicals (such as those used in detergents, bleaching, relaxing, dyeing, and permanent waving), and/or UV radiation (such as, for example, from light sources).

"At least one" as used herein means one or more and thus includes individual components as well as mixtures/combinations.

"Heating" refers to the use of elevated temperature (*i.e.*, above 100°C). In one embodiment, the heating in the inventive method may be provided by directly contacting the at least one keratinous fiber with a heat source, *e.g.*, by heat styling of the at least one keratinous fiber. Non-limiting examples of heat styling by direct contact with the at least one keratinous fiber include flat ironing, and curling methods using elevated temperatures (such as, for example, setting hair in curlers and heating, and curling with a curling iron and/or hot rollers). In another embodiment, the heating in the inventive method may be provided by heating the at least one keratinous fiber with a heat source which may not directly contact the at least one keratinous fiber. Non-limiting examples of heat sources which may not directly contact the at least one keratinous fiber include blow dryers, hood dryers, heating caps and steamers.

"A heat-activated" composition, as used herein, refers to a composition which, for example, protects the at least one keratinous fiber better than the same composition which is not heated during or after application of the composition. Another example includes a composition which repairs the at least one keratinous fiber better than the same composition which is not heated during or after application.

"Keratinous fibers" as defined herein may be human keratinous fibers, and may be chosen from, for example, hair.

"Oligosaccharides" as defined herein refers to compounds generally comprising from two to ten monosaccharide units, which may be identical or different, bonded together.

"Polysaccharides" as defined herein refers to compounds generally comprising greater than ten monosaccharide units, which may be identical or different, bonded together.

"Protected" as defined herein means that the at least one keratinous fiber demonstrated a greater degree of preservation of the α-structure and the tensile strength.

"Repairing" as used herein means that the at least one damaged keratinous fiber demonstrated an increase in α-structure and/or tensile strength following treatment of the at least one damaged keratinous fiber with the compositions of the invention.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

Brief Description of the Drawing

Figure 1: A DSC (Differential Scanning Calorimetry) thermogram of normal brown hair. The hair sample was heated from 25°C to 300°C at a heating rate of 20°C/min. Peak A is the water release peak. Doublet peak B corresponds to the melting or rearrangement of the α-structure and its matrix contribution.

Reference will now be made in detail to exemplary embodiments of the present invention.

As described above, sugars have been used in hair care compositions and other treatments for their moisture retaining properties. However, it was unexpectedly discovered by the present inventors that, in addition to retaining moisture, a certain class of sugars provided protection to keratinous fibers from at least one type of extrinsic damage and also repaired keratinous fibers damaged by such extrinsic conditions. In particular with respect to hair, compounds chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain were found to protect the α-structure of the hair cortex. This is particularly true when the compounds are applied to the hair, and then the hair is heated.

Thus, the invention provides methods for protecting at least one keratinous fiber from extrinsic damage or for repairing at least one keratinous fiber following extrinsic damage comprising applying to the at least one keratinous fiber a composition comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, and heating the at least one keratinous fiber. The composition may be applied to the at least one keratinous fiber prior to and/or during the heating of the at least one keratinous fiber. Further, the at least one compound is present in an amount effective to protect the at least one keratinous fiber from extrinsic damage and/or to repair the at least one keratinous fiber, depending on the embodiment. In one embodiment, the composition both protects the at least one

keratinous fiber from extrinsic damage and repairs the at least one damaged keratinous fiber. The composition may further comprise at least one additional sugar.

The present invention provides also methods for protecting at least one keratinous fiber from extrinsic damage or for repairing at least one keratinous fiber following extrinsic damage comprising applying to the at least one keratinous fiber a composition comprising (i) at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, and (ii) at least one film forming agent, and heating the at least one keratinous fiber. The composition may be applied to the at least one keratinous fiber prior to or during heating of the at least one keratinous fiber. Further, the at least one compound and the at least one film forming agent are present in an amount effective either to protect the at least one keratinous fiber from extrinsic damage or to repair the at least one keratinous fiber, depending on the embodiment. In one embodiment, the composition both protects the at least one keratinous fiber from extrinsic damage and repairs the at least one damaged keratinous fiber. The composition may further comprise at least one additional sugar.

The present invention also provides compositions for protecting at least one keratinous fiber from extrinsic damage or for repairing at least one keratinous fiber following extrinsic damage comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, and, optionally at least one film forming agent, wherein the at least one compound, and, optionally, the at

least one film forming agent, are present in an amount effective to protect the at least one keratinous fiber from extrinsic damage or to repair at least one damaged keratinous fiber. In one embodiment, the composition is heat-activated. In another embodiment, the composition both protects the at least one keratinous fiber from extrinsic damage and repairs the at least one damaged keratinous fiber. The composition may further comprise at least one additional sugar and/or at least one film forming agent.

Not to be limited as to theory, but, as described above, the mechanical properties of the hair are determined by the cortex, wherein coiled protein molecules are arranged in a specific and highly organized pattern (the "α-structure") representing a degree of crystallinity in the hair fiber. As the α-structure is sensitive to extrinsic conditions, the extent of damage to the hair by extrinsic conditions can be monitored by monitoring changes in the α-structure.

In addition to X-ray diffraction, which allows one to determine the presence of a crystalline structure in the material, one may determine a relative amount of crystallinity in the material by employing a much simpler method called differential scanning calorimetry (DSC). DSC is based on the fact that all materials have an ability to absorb a certain amount of energy on heating, and this amount of energy is sensitive to changes in the structure, phase, and composition of the material. For example, the amount of energy a material absorbs may change when a material undergoes a change in crystal structure, a phase transition, such as melting, or the loss of water.

In DSC, a small sample of material is sealed in a cell and the material is heated

at a steady rate. The power required to achieve a certain temperature in the sample is compared to the power required to achieve the same temperature in the empty cell, which serves as a reference. The difference in the amount of heat input between the reference and the sample is recorded as a function of temperature. In the absence of phase transitions in the sample, there should be no change in heat input to maintain a constant temperature.

However, the amount of energy needed to maintain the temperature changes when the material undergoes a change in crystal structure, a phase transition, or the loss of water. For example, in a case where the material loses water, the water loss is an endothermic process, *i.e.,* it requires energy. Therefore, the sample will absorb more energy as compared to the reference in order for the sample to remain at the same temperature as the reference. This process will be registered as an increase in the heat flow above the baseline in the form of a peak. The more water contained in the sample, the greater the peak area.

For example, it is well known that water plays an important role in physico-chemical properties of the keratin fibers. The moisture content in dry fibers depends on both the relative humidity of the environment and on the condition of the hair. The water in the hair fiber can exist in three forms: 1) water adsorbed strongly on binding sites, 2) water adsorbed weakly on binding sites, and 3) loosely bound or free water. Based on the values for the heat of hydration found for each of the groups, it can be speculated that strongly bound binding sites include amino groups (hydration heat of

16.8 kcal/mole), while weakly bound binding sites may include hydroxyl and carboxylic groups (5.7 kcal/mole and 7.4 kcal/mole, respectively).

Using DSC, one can observe the loss of water due to exposure of the hair to heat. The loosely bound and free water should be removed around 100°C, while the release of the strongly bound water should be observed above 140°C. In the DSC of keratinous fibers, a broad endotherm is observed from 75°C to 200°C, which is initially related to removal of the free water, and then to the removal of more strongly bound water (See Figure 1).

In a similar way, if a melting process or any other change in the crystal structure takes place in the sample, it requires additional energy, and thus will be manifested in the form of a peak on the DSC curve. The greater the degree of crystallinity or organized structure in the sample, the greater the peak area that will be observed. Therefore, DSC is also an excellent tool for observing the change in the α-structure of keratinous fibers and can help indicate hair damage.

From 20% to 30% of the hair cortex occurs in a highly organized (α-helical) form. Milczarek et al, Colloid Polym. Sci., 270, 1106-1115 (1992). When the hair is heated above 230°C, a doublet peak is usually observed in DSC, which has been interpreted in terms of a first peak corresponding to the helix melting points (microfibrillar origin) and a second peak corresponding to cystine decomposition (matrix origin). Spei and Holzem, Colloid & Polymer Sci. 265, 965-970 (1987). However, further studies have shown that the first peak of the doublet, the microfibrillar peak, is more specifically a helix

unfolding, superimposed by various decomposition reactions. Id. Herein, the term α-structure is associated with the doublet peak or peak area though technically the doublet area includes both a crystalline (microfibrillar) and non-crystalline (matrix) contribution. The α-structure represents the overall integrity of the fiber in an unstressed state. (See Figure 1).

The greater the peak area, usually expressed in Joules per gram of hair, the higher the percentage of the hair cortex in the α-structure form. The DSC peak, at 210-250°C, also coincides with the disappearance of the alpha-pattern in the X-ray diffraction. Sandhu and Robbins, J. Soc. Cosmet. Chem., 44, 163-175 (1993). In other words, when normal hair is damaged by heat, chemical treatment, or UV irradiation, a decrease in the doublet peak area of the DSC is observed and the amount of damage can be quantified by the peak area. The correlation between a decrease in DSC peak area and damage to the hair fibers is further verified by a corresponding decrease in the number of disulfide bonds (expressed as half-cystine) in the hair (see Table 1 below). A decrease in the number of disulfide bonds corresponds to a breakdown in the chemical structure of the hair.

Table 1. Effect of Chemical Treatment, Heat, and UV Irradiation on Chemical and Physical Properties of the Hair

Hair type	Doublet peak area (J/g hair)	Half-Cystine (micromole/g hair)
Normal blonde hair	81.57 +/- 8.28	918.7 +/- 165.8
Blonde hair after:		
Perm	54.63 +/- 25.78	810.1 +/- 135.9
Bleach	53.22 +/- 13.12	740.1 +/- 45.9
UV (180 h)	13.98 +/- 11.78	629.7 +/- 8.8
Heat (12 cycles at 130°C)*	18.63 +/- 8.56	654.3 +/- 50.7

*12 cycles, 1 min each, at 130°C

The detrimental changes in the chemical composition and in the amount of the hair crystallinity are also accompanied by cuticle loss and/or a decrease in the tensile strength. Shown in Table 2 below is the correlation between the doublet peak area and the wet tensile strength of normal and damaged hair. The wet tensile strength is expressed as the work required to stretch the wet fiber to 25% of its original length.

Table 2. Correlation between the Doublet Peak Area and the Wet Tensile Strength of Normal and Damaged Hair

Hair type	Doublet Peak Area (J/g hair) n=5 DSC tests	Work 25% (J/m^2) n=100 fibers
Normal blonde hair	25.00 +/- 4.90	555.0 +/- 122
Blonde hair after:		
Heat (12 cycles at 130°C)*	8.39 +/- 0.72	370 +/- 138
Bleach	6.90 +/- 0.55	222 +/- 93

*12 cycles, 1 min each, at 130°C

The above demonstrates that damage to the hair involves a decrease in the percentage of the hair cortex in the α-structure form. The inventors have found, however, that the damage to the α-structure can be prevented or at least lessened if the hair is treated with a composition comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain

(Nomenclature: C3 - triose, C4 - tetrose, C5 - pentose, C6 - hexose) and then heated. Hexoses and other large monosaccharides substituted with at least one C_1 to C_{22} carbon chain do not appear to provide similar protection to the hair. The composition may be applied prior to and/or during heating of the keratinous fibers.

The present invention is thus also drawn to compositions for protecting at least one keratinous fiber from extrinsic damage and/or for repairing at least one keratinous fiber following extrinsic damage comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain, and optionally, at least one film forming agent. In one embodiment, the composition is heat-activated.

C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain may also reduce cuticle loss and/or facilitate repair or re-building of the α-structure of the fibers following damage from extrinsic conditions. Although the inventors do not intend to be limited as to theory, the ability of these C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain to repair keratinous fibers may be due to a reaction between the hair and these C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain. When hair was treated with a composition comprising at least one C_3 to C_5 monosaccharide substituted with at least one C_1 to C_{22} carbon chain prior to heat application, changes in the chemical composition of the hair were observed. More specifically, the amount of lysine and arginine decreased,

indicating what appears to be a Schiff base reaction between the aldehyde groups of the monosaccharides and the amine groups of the hair fibers.

According to certain embodiments of the present invention, the C_3 to C_5 monosaccharides are hydrophobic, and may be used in conjunction with at least one film-forming agent, such as, for example, film-forming polymers and resins. Thus, the at least one composition may further comprise at least one film forming agent. The at least one film forming agent may be chosen from film forming polymers and film forming resins. Non-limiting examples of the at least one film forming agent are those listed at pages 1744 to 1747 of the CTFA International Cosmetic Ingredient Dictionary, 8th edition (2000). In one embodiment, the at least one film forming agent may be neutralized. Non-limiting examples of the at least one film forming agent are those disclosed in WO 01/18096, the disclosure of which is incorporated herein by reference. According to the present invention, the at least one film forming agent may be present in an amount generally ranging from 0.01% to 30% of active material by weight relative to the total weight of the composition, such as from 0.1% to 10% of active material by weight. One of ordinary skill in the art will recognize that the at least one film forming agent according to the present invention may be commercially available, and may come from suppliers in the form of a dilute solution. The amounts of the at least one film forming agent disclosed herein therefore reflect the weight percent of active material.

The C_3 to C_5 monosaccharides according to the present invention may be chosen from any triose, tetrose and pentose. Further, the C_3 to C_5 monosaccharides

can be chosen from the D-form, L-form and mixtures of any of the foregoing. Non-limiting examples of C_3 to C_5 monosaccharides include aldopentoses (such as xylose, arabinose, lyxose, and ribose), ketopentoses (such as ribulose and xylulose), aldotetroses (such as erythrose and treose), ketotetroses (such as erythrulose), aldotrioses (such as glyceraldehyde) and ketotrioses (such as dihydroxyacetone). The C_3 to C_5 monosaccharides may be chosen from C_3 to C_5 monosaccharides comprising aldehyde groups (aldoses), furanoses and other ring structures. The C_3 to C_5 monosaccharides may be further substituted with at least one group different from the C_1 to C_{22} carbon chain.

Derivatives of C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain may be used as the at least one compound of the present invention. For example, ammonias or primary amines may react with the aldehyde or ketone group of a sugar to form an imine derivative (*i.e.,* a compound containing the functional group C=N). These imine compounds are sometimes also referred to as Schiff bases. Other non-limiting examples of derivatives of C_3 to C_5 monosaccharides are hemiacetal derivatives of C_3 to C_5 monosaccharides, hemiketal derivatives of C_3 to C_5 monosaccharides and any oxidized derivatives of C_3 to C_5 monosaccharides. These derivatives may be formed, for example, from the reaction of the aldehyde or ketone group of a sugar with an alcohol. Other exemplary derivatives of C_3 to C_5 monosaccharides may also include, but are not limited to, oligosaccharides derived from C_3 to C_5 monosaccharides, such as xylobiose. As previously mentioned, the at

least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain may be further substituted with at least one group different from the at least one C_1 to C_{22} carbon chain. Thus, in one embodiment, the derivatives of C_3 to C_5 monosaccharides may be further substituted with at least one group different from the at least one C_1 to C_{22} carbon chain.

According to the present invention, the at least one C_1 to C_{22} carbon chain may be chosen from linear, branched and cyclic C_1 to C_{22} carbon chains, which are saturated or unsaturated. The at least one C_1 to C_{22} carbon chain may optionally be substituted. In one embodiment, the at least one C_1 to C_{22} carbon chain is chosen from C_{16} to C_{18} carbon chains. In another embodiment, the at least one C_1 to C_{22} carbon chain is chosen from C_{16} carbon chains and C_{18} carbon chains. Non-limiting examples of C_{16} carbon chains are linear hexadecyl chains, and non-limiting examples of C_{18} carbon chains are linear octadecyl chains.

Further, the C_3 to C_5 monosaccharides may be substituted with the at least one C_1 to C_{22} carbon chain at any position on the sugar. For example, in one embodiment, a C_3 to C_5 monosaccharide is substituted with at least one C_1 to C_{22} carbon chain at the C1 position of the C_3 to C_5 monosaccharide. In another embodiment, a C_3 to C_5 monosaccharide is substituted with the at least one C_1 to C_{22} carbon chain at at least one of the hydroxyl groups of the C_3 to C_5 monosaccharide. As used herein, substituted at at least one of the hydroxyl groups of a C_3 to C_5 monosaccharide means at least one of substitution on the hydroxyl group itself (*i.e.*, formation of an ether

linkage between the C_3 to C_5 monosaccharide and the C_1 to C_{22} carbon chain) and substitution on the carbon atom to which the hydroxyl group is commonly bonded. Further, the C_3 to C_5 monosaccharides may be substituted with the at least one C_1 to C_{22} carbon chain at a carbon atom bearing no hydroxyl groups (*i.e.*, a CH_2 within the C_3 to C_5 monosaccharide or a carbon atom within the C_3 to C_5 monosaccharide bearing substituents other than a hydroxyl group). Further, the C_3 to C_5 monosaccharides may be further substituted with at least one substituent different from the at least one C_1 to C_{22} carbon chain.

According to the present invention, the at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain is present in the composition in an amount generally ranging from 0.01% to 10% by weight relative to the total weight of the composition, such as from 0.1% to 5% by weight.

The compositions of the present invention as well as those of the inventive methods may further comprise at least one additional sugar which is different from the at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain. The at least one additional sugar may, for example, aid in moisture retention. The effectiveness of a sugar in aiding in moisture retention may be measured by monitoring the DSC peak at a temperature ranging from 75°C to 200°C.

The at least one additional sugar may be chosen from any sugar, carbohydrate and carbohydrate moiety. Non-limiting examples of the at least one additional sugar are monosaccharides, which include, but are not limited to, three to seven carbon

sugars such as pentoses (for example, ribose, arabinose, xylose, lyxose, ribulose, and xylulose) and hexoses (for example, allose, altrose, glucose, mannose, gulose, idose, galactose, talose, sorbose, psicose, fructose, and tagatose); oligosaccharides such as disaccharides (such as maltose, sucrose, cellobiose, trehalose and lactose); and polysaccharides such as starch, dextrins, cellulose and glycogen. In one embodiment, the at least one additional sugar of the invention is chosen from any aldoses and ketoses.

Further, the at least one additional sugar may be substituted or unsubstituted. For example, the at least one additional sugar may be substituted with at least one C_1 to C_{22} carbon chain. In one embodiment, the at least one C_1 to C_{22} carbon chain is chosen from linear, branched and cyclic C_1 to C_{22} carbon chains, which are saturated or unsaturated. For example, the at least one C_1 to C_{22} carbon chain may be chosen from C_{16} to C_{18} carbon chains (such as C_{16} carbon chains and C_{18} carbon chains). Further, for example, C_{16} carbon chains may be chosen from linear hexadecyl chains and C_{18} carbon chains may be chosen from linear octadecyl chains. In one embodiment, the at least one additional sugar is substituted with at least one C_1 to C_{22} carbon chain at the C1 position of the at least additional one sugar.

According to the present invention, the at least one additional sugar is present in the composition in an amount generally ranging from 0.01% to 10% by weight relative to the total weight of the composition, such as from 0.1% to 5% by weight.

The compositions of the present invention and those used in the methods of the present invention may be in the form of a liquid, an oil, a paste, a stick, a dispersion, an

emulsion, a lotion, a gel, or a cream. Further, these compositions may further comprise at least one suitable additive chosen from additives commonly used in compositions for keratinous fibers. Non-limiting examples of the at least one suitable additive include anionic surfactants, cationic surfactants, nonionic surfactants, amphoteric surfactants, fragrances, penetrating agents, antioxidants, sequestering agents, opacifying agents, solubilizing agents, emollients, colorants, screening agents (such as sunscreens and UV filters), preserving agents, proteins, vitamins, silicones, polymers such as thickening polymers, plant oils, mineral oils, synthetic oils and any other additive conventionally used in compositions for the care and/or treatment of keratinous fibers.

Needless to say, a person skilled in the art will take care to select the at least one suitable additive such that the advantageous properties of the composition in accordance with the invention are not, or are not substantially, adversely affected by the addition(s) envisaged.

The compositions of the present invention and those used in the methods of the present invention may also be provided as one-part compositions comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain and, optionally, at least one additional sugar, and further, optionally, at least one film forming agent, or in the form of a multi-component treatment or kit. The skilled artisan, based on the stability of the composition and the application envisaged, will be able to determine how the composition and/or multicomponent

compositions should be stored and mixed. For example, simple sugars such as C_3 to C_5 monosaccharides are known to be stable at pH levels ranging from 4 to 9. In compositions where the pH range is below or above these levels, the sugars would be stored separately and added to the composition only at the time of application.

Thus, the present invention also relates to a kit for protecting at least one keratinous fiber from extrinsic damage or for repairing at least one keratinous fiber following extrinsic damage comprising at least one compartment, wherein a first compartment comprises a first composition comprising at least one compound chosen from C_3 to C_5 monosaccharides substituted with at least one C_1 to C_{22} carbon chain. In one embodiment, the first composition further comprises at least one additional sugar, different from the at least one compound, while in another embodiment, the first composition further comprises at least one film forming agent.

According to one aspect of the invention, the at least one compound suitable for the present invention is a mixture of pentoses substituted with at least one C_1 to C_{22} carbon chain. XYLIANCE brand modified pentoses is a blend of hexadecyl glycosides and octadecyl glycosides wherein the glycosides comprise D-xylosides, L-arabinosides, and D-glucosides. XYLIANCE may be obtained from Soliance, Route de Bazancourt - 51110 Pomacle, France.

Other than in the operating examples, or where otherwise indicated, all numbers expressing quantities of ingredients, reaction conditions, and so forth used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical

parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should be construed in light of the number of significant digits and ordinary rounding approaches.

Notwithstanding that the numerical ranges and parameters setting forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contains certain errors necessarily resulting from the standard deviation found in their respective testing measurements. The following examples are intended to illustrate the invention without limiting the scope as a result.

Examples

Example 1. Effect of UV/Thermal History on the Structure of "Virgin" (Chemically Non-treated) Hair

A swatch of Caucasian hair, dark blonde, coarse and wavy, 5 inches long and cut from the root, was tested. The hair had never been treated in any way that would cause changes in its chemical composition such as perming, relaxing, or coloring. The hair had only been subject to shampoo, conditioner (including oil treatment), styling aids, and blow drying, as well as the normal conditions of nature.

The swatch was divided into two sections, each 2.5 inches in length. For the DSC experiments, three samples of finely cut hair was accurately taken from the following parts of the swatch:

- the extreme root end
- the 2.5 inch length, and
- the 5.0 inch length.

In the DSC experiments (using DSC-6 with Autosampler, Perkin Elmer), the hair was cut in small fragments (1-2 mm) and sealed in 40 ml aluminum pans that were punctured prior to heating, resulting in a 50 micron laser-drilled opening in the pan lid. The hair was heated from 25°C to 300°C at a heating rate of 20°C/min. Three runs per section were performed. The results were averaged and standard deviations determined.

The two sections were also tested for wet tensile strength using the fiber tensile testing instrument Dia-Stron (50 fibers per test). The following parameters were determined: Young's Modulus (the spring constant, measured in N/m^2); Work to stretch

the hair fiber 25% of its length (J/m^2); Extension to Break (how far hair can be stretched before breaking, measured in % of hair length); Work to Break (J/m^2).

The DSC results are presented in Table 3, and the Dia-Stron data in Table 4. In both tables, the extreme root part of the hair is taken as the zero point. These results show the intrinsic loss of α-structure in hair due to normal conditions, *i.e.*, they illustrate how the damage is greater the further you go from the root.

Table 3. Alpha-structure of Normal Hair as a Function of the Hair Length

Hair Length, inches	Doublet Peak Area, J/g hair
0	37.75 +/- 5.91
2.5	27.28 +/- 10.70
5.0	21.36 +/- 7.36

Table 4. Wet Tensile Strength of Normal Hair as a Function of the Hair Length

Hair Length (Inches)	Young's Modulus (MN/m^2)	Work 25% (J/m^2)	Break (%)	Work to Break (J/m^2)
0 to 2.5	732 +/- 114	395 +/- 103	60.3 +/- 4.3	1690 +/- 442
2.5 to 5.0	613 +/- 116	230 +/- 49	58.8 +/- 8.6	1100 +/- 232

The following examples shows the ability of modified pentoses to protect the internal structure of hair when applied to at least one keratinous fiber and the at least one keratinous fiber is heated.

Example 2. Hair Protection Effects of XYLIANCE

Bleached hair swatches (2 g., 6.5-7.5 in.) were treated with alcoholic solutions that contained 3% Amphomer LV-71; and 3% Amphomer LV-71 and 1% XYLIANCE (modified pentoses as described above). The hair was then blow dried, and styled with a curling iron for 1 minute. The middle and the tip portion of the hair were analyzed by DSC. The results are shown in Table 5.

Table 5. Total Area of the Doublet from the DSC Analysis of Heat Treated Hair

Treatment	Middle Portion (J/g)	Tip Portion (J/g)
Amphomer LV-71	7.11	7.45
Amphomer LV-71 + XYLIANCE	8.98	9.12

The data indicate that XYLIANCE protected the internal structure of the heat-treated hair.